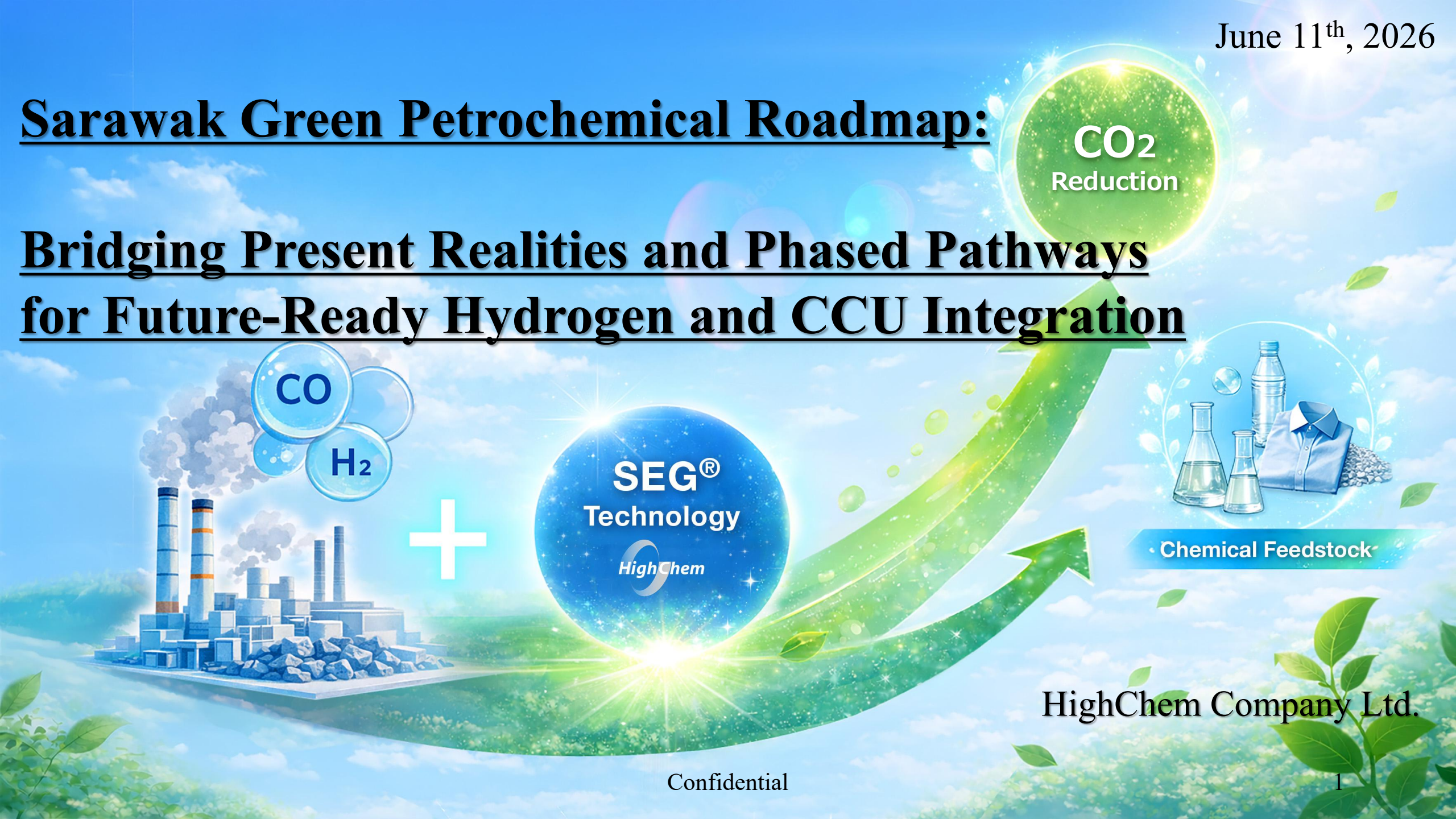
June 11th, 2026

# Sarawak Green Petrochemical Roadmap:

# Bridging Present Realities and Phased Pathways for Future-Ready Hydrogen and CCU Integration




HighChem Company Ltd.

# Introduction of HighChem Company Limited


President and Representative Director

Yuichi Taka

**28 yrs**

Established

**173.9 Billion yen**

Sales FY 2025

(Jan. 2025 – Dec. 2025)

**668**

Group Employee

(As of December 31, 2025)

**27**

Number of Locations

**4**

Research Base

**4500+**

Japan: 700+
China: 3,500+
Others: 300+

Number of Client Companies

**8000+**

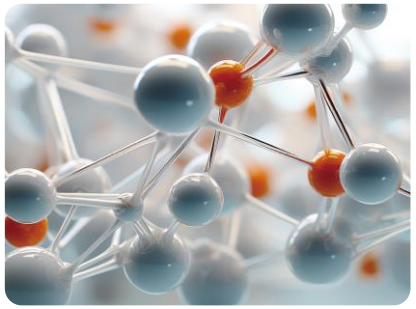
Number of products available

**160+**

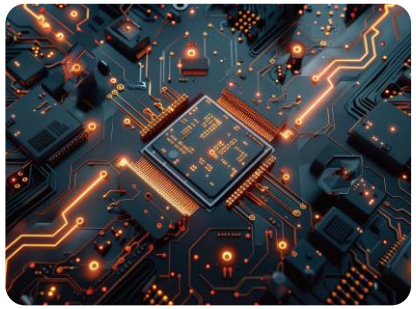
Number of patents granted globally

(Including pending applications and transfers)

## Business Fields



**Core Materials**



**Electronics**

**Life Science**

**Carbon Design**

# Executive Summary : Hydrogen Barrier

Carbon Capture and Utilization (CCU) is critical for net-zero, yet faces an economic hurdle:

**The cost of Hydrogen**

- Converting $CO_2$ to chemicals/fuels require massive $H_2$ input.
- High $H_2$ prices remain a barrier to commercial scale.

- Regulatory support ($CO_2$ Tax, Subsidy, etc.)
- Green premium on final products
- Selecting final products which requires minimum $H_2$ for $CO_2$ conversion

# Why Polyester ?

## Stochiometric Advantage

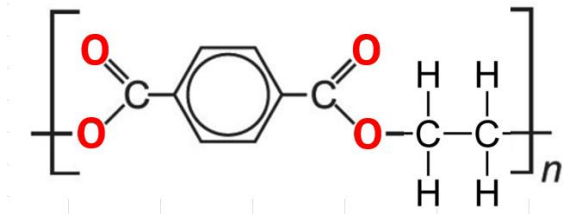
When converting $CO_2$ into useful products, Hydrogen is used to remove Oxygen from $CO_2$ for further reaction.

Unlike typical polymer/ fuel such as polyethylene/ polypropylene/SAF/etc., Polyester contains oxygen atom in its ester function group and less need to remove Oxygen.

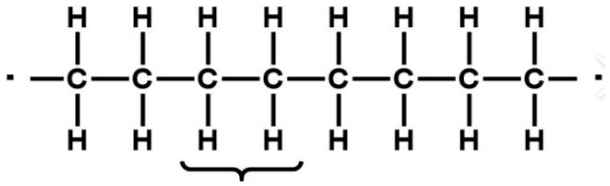
Therefore, Polyester needs less Hydrogen to convert from $CO_2$

Stoichiometric Comparison

**Polyester (PET)**
Requires 0.21 MT of $H_2$ per 1 MT product



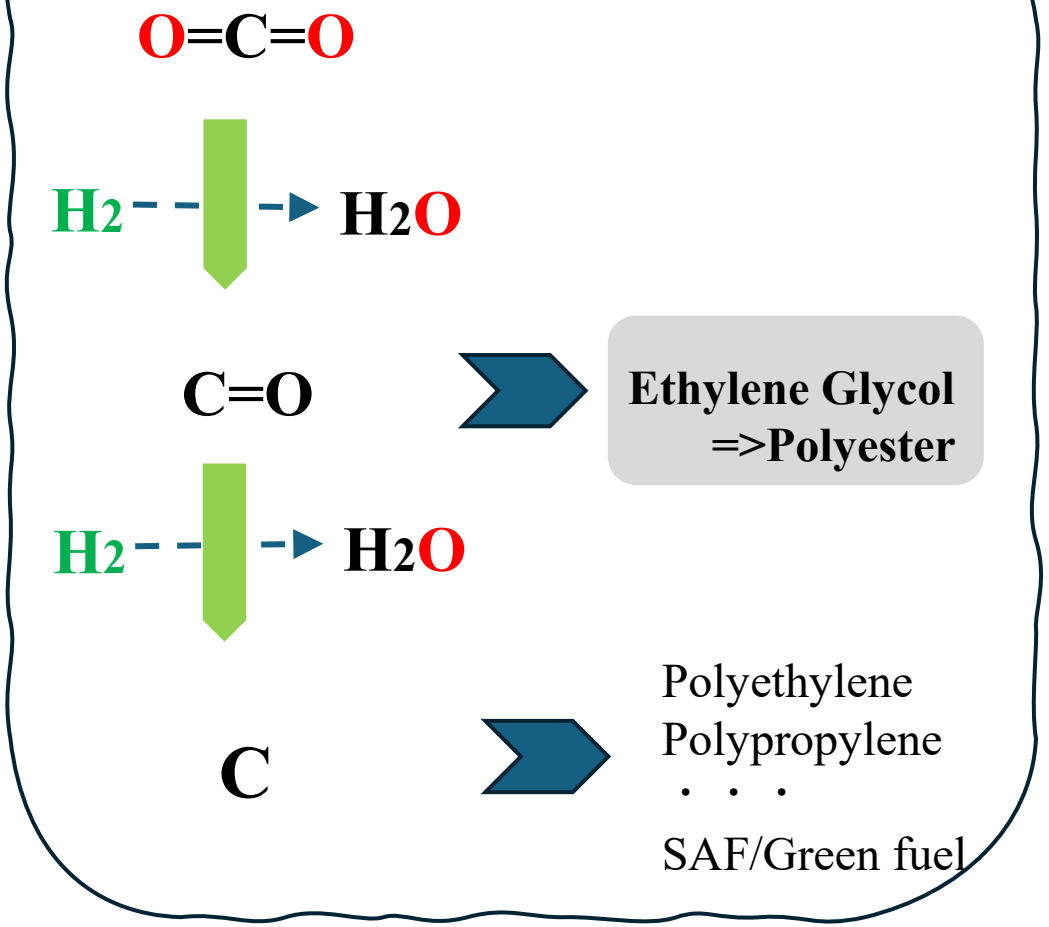
**PE (Polyethylene)**
Requires 0.43 MT of $H_2$ per 1 MT product.



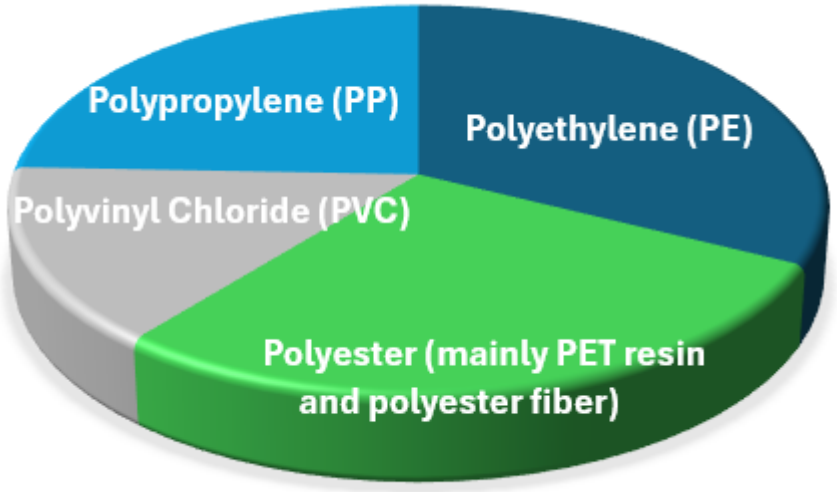
50%

**Lower $H_2$ Consumption**

**Simplified $CO_2$ conversion mechanism**



# Scale: The Ideal Sink for CCU




Global warming urges to sequestrate massive $CO_2$. When selecting CCU product, it must have huge market size.

Polyester is the 2nd largest general-purpose resin globally, providing the necessary scale for significant $CO_2$ Sequestration.

| Global Demand @ 2024 | (Million Tons per Year) | Remarks |
|---|---|---|
| Polyethylene (PE) | 134 | Includes HDPE, LDPE, and LLDPE |
| Polypropylene (PP) | 101 | Mainly used in packaging, automotive, and fiber applications |
| Polyvinyl Chloride (PVC) | 61 | Primarily used in construction materials and pipes |
| Polyester (mainly PET resin and polyester fiber) | 118 | Includes PET bottles and textile applications |

# Why HighChem ? - Proven Technology

**Proven Track Record**
25 licenses executed in 10 years, totaling 10 million tons annual production capacity.

**Zero Technology Risk**
World-class plant scale with operational reliability verified at major sites.

**Cost Advantage**
Economically superior route to Ethylene Glycol from CO/$CO_2$.

HighChem SEG® reference plant

| No | Owner | Raw material | Capacity (kMt/y) | Status |
|---|---|---|---|---|
| 1 | QianXi Coal Chemical Company | Coal | 300 | Operate from June,2018 |
| 2 | Xinjiang TianYe Group 1 | Calcium carbide furnace tail gas | 50 | Operate from Jan,2013 |
| 3 | Xinjiang TianYe Group 2 | Coal | 200 | Operate from Mar,2015 |
| 4 | Xinjiang TianYe Group 4 | Coal | 100 | Operate from May,2018 |
| 5 | Yangmei Group (Sjouyang) | Coal | 200 | Operate from June,2018 |
| 6 | Xinjiang TianYe Group 3 | Coal | 600 | Operate from Sep,2019 |
| 7 | Anhui Hongsifang Co.,Ltd | Coal | 300 | Operate from Sep,2018 |
| 8 | Xinjiang Tianying Co.,Ltd | Natural Gas | 150 | Operate from July,2018 |
| 9 | Shaanxi Weihe Chemical Company | Coal | 300 | Operate from Feb,2021 |
| 10 | Lihuayi Group | Coal | 200 | Operate from Jan,2018 |
| 11 | Hubei Sanning Chemical Company | Coal | 600 | Operate from May,2021 |
| 12 | Shanxi Wo energy Company | Coke oven gas +converter gas | 300 | Operate from Aug,2019 |
| 13 | Shanxi Meijing Company | Coke oven gas +converter gas | 300 | Operate from Feb,2022 |
| 14 | Shaanxi Coal and Chemical Industry Group | Coal | 1800 | Operate from Sep,2022 |
| 15 | Ningxia Changyi (Kunpeng) . | Coal | 200 | ~~suspended~~ Under Commission Oct.,25 |
| 16 | Zhejiang Tongkun Group (Xinjiang) | Natural gas | 600*2 | Operate from Dec,2023 |
| 17 | Xilinguolesu alkali Co.,Ltd | Coal | 300 | Suspended |
| 18 | CNCEC (Inner Mongolia) New Materrals (Mongolia Cornel chemical Co.,Ltd)I | Coal | 2*300 | ~~Suspended~~ Operate from Sep. 2024 |
| 19 | Shanxi linxin Coal Industry Company | Coal | 400 | Suspended |
| 20 | Shanxi Songlan Coal Industry Company | Coal | 400 | Suspended |
| 21 | Inner Mongolia Datang keshenke NG Co.，Ltd | Coal | 400 | Suspended |
| 22 | Inner Mongolia Datang huxing Coal to NG Co.,Ltd | Coal | 400 | Suspended |
| 23 | Xinjiang zhibeng Chemical Co.,Ltd | Coal | 400 | Suspended |
| 24 | Inner Mongolia kailuan Coal chemical Co.,Ltd | Coal | 400 | Suspended |
| 25 | Shanxi linxin Coal Industry Company | Coal | 200 | Suspended |

25 Licensed Plants with a total capacity of 10.5 million ton/y

World's largest SEG® plant

HighChem — SCCIG
1.8 million ton/y since 2022

The entire process for polyester-grade EG was successfully started up within 30 days, and 100% loading operation within 48 days.

# Certified Impact: Verified Carbon Performance at Scale

## ISO 14064-2 Verification

Our license technology has obtained significant decarbonization certification.

Utilizing off-gas to produce valuable EG while mitigating climate impact:

**570,000**

**Tons $CO_2$/Year Mitigated**

Verified via ISO 14064-2 Standard at 300,000 Tons/Year MEG Capacity.

Statement of Conformity CN21/21440

SGS

**Greenhouse Gas Verification Statement**

The information of Greenhouse Gas emissions in 1 September, 2020 to 31 August, 2021 of

**Shanxi Woenergy Chemical Industrial Technology Co., Ltd.**

Project name: Recovery and reuse of coke oven gas and converter gas as raw materials to produce 300kt/a ethylene glycol project

Project boundary: The production facilities and auxiliary involved in the project located in the northeast of the intersection of Liheng Avenue and Yujin Road, Gaoxian Town, Quwo County, Linfen City, Shanxi Province, P.R. China

has been verified in accordance with ISO 14064-3:2019 as meeting the requirements of

ISO 14064-2:2019

Compared with baseline scenario

Scenario 1: Coke oven gas produced by coking plant and converter gas produced by iron and steel plant are directly burned and discharged.

Scenario 2: Naphtha to ethylene glycol process: Naphtha cracking to ethylene, ethylene oxidation to ethylene oxide and ethylene oxide catalytic hydration to ethylene glycol.,

have reduced greenhouse gas emissions/ increased greenhouse gas removals 574,872.54 tonnes of $CO_2e$

Authorised by

DATE: 24 September 2021

# Catalyst Business

## Catalyst manufacturing base

HighChem established a catalyst factory in Nantong City, Jiangsu Province in 2011, and has established a supply system for various catalysts, including the supply of DMO and EG catalysts to SEG® licensed companies.

| | |
|---|---|
| Established | August 2011 |
| Total floor area | 40,499.79㎡ |
| Number of employees | Approximately 170 |
| Annual production capacity | ・Palladium catalyst 1,500 tons/year,<br>・Copper catalyst 1,500 tons/year<br>・SCR low temperature denitration catalyst 1,000 tons/year<br>・DMC synthesis catalyst 500 tons/year |

Nantong Catalyst Factory

## In-house R&D system

HighChem owns three research centers in Japan and China with about 50 researchers. At the Tokyo Research Center, we conduct high-quality basic research by building long-term cooperative relationships with university laboratories and corporate R&D institutions. In addition, the Nantong Research Laboratory, where the catalyst factory is located, is capable of delivering pilots and scale-ups that are close to the industrial level, while the Shanghai Research Laboratory can deliver industrial level results such as process design and engineering.

Tokyo Research Center

Shanghai Research Center

Nantong Research Center

# The Sarawak Hub: A Strategic Alliance with the world Giant

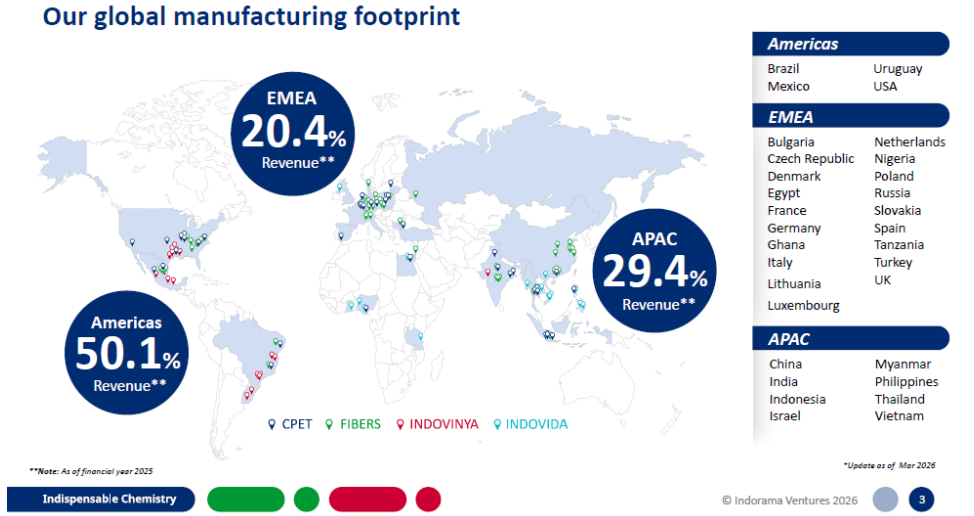
## Partnering with Indorama Ventures

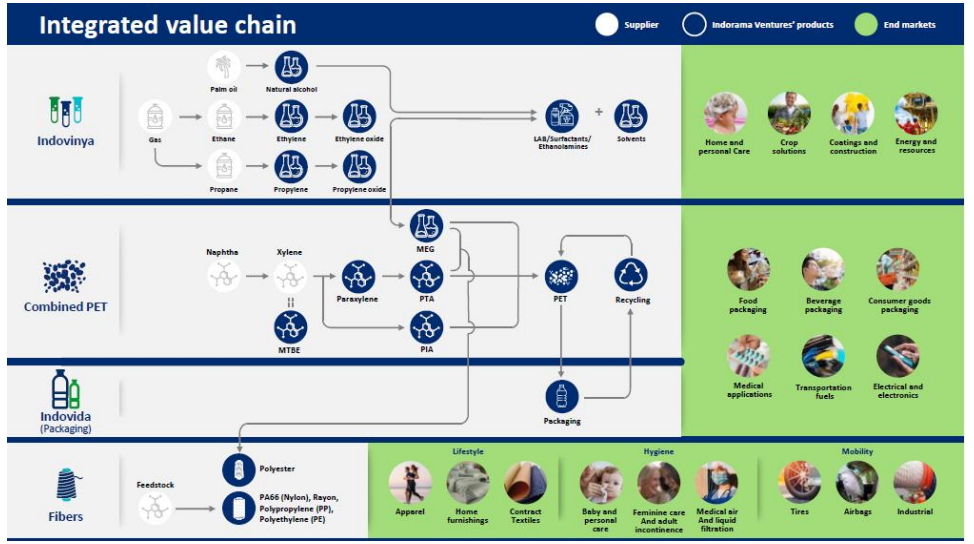
**Indorama Ventures**, the world's largest PET manufacturer outside China, is partnering in the project study.

**Global Reach**: World-class scale and market access.

Strategic Location: Attracting Indorama to Sarawak is the key to global CCU leadership.

Future Proof: Establishing Sarawak as the Asian center for sustainable polyester and petrochemicals.



# Phased Strategic Roadmap: From Foundation to Full Circularity

## Foundation (Phase 1)

Utilize Industrial waste gas for decarbonization. Top up natural gas for economy of scale.

## Scaling CCU (Phase 2)

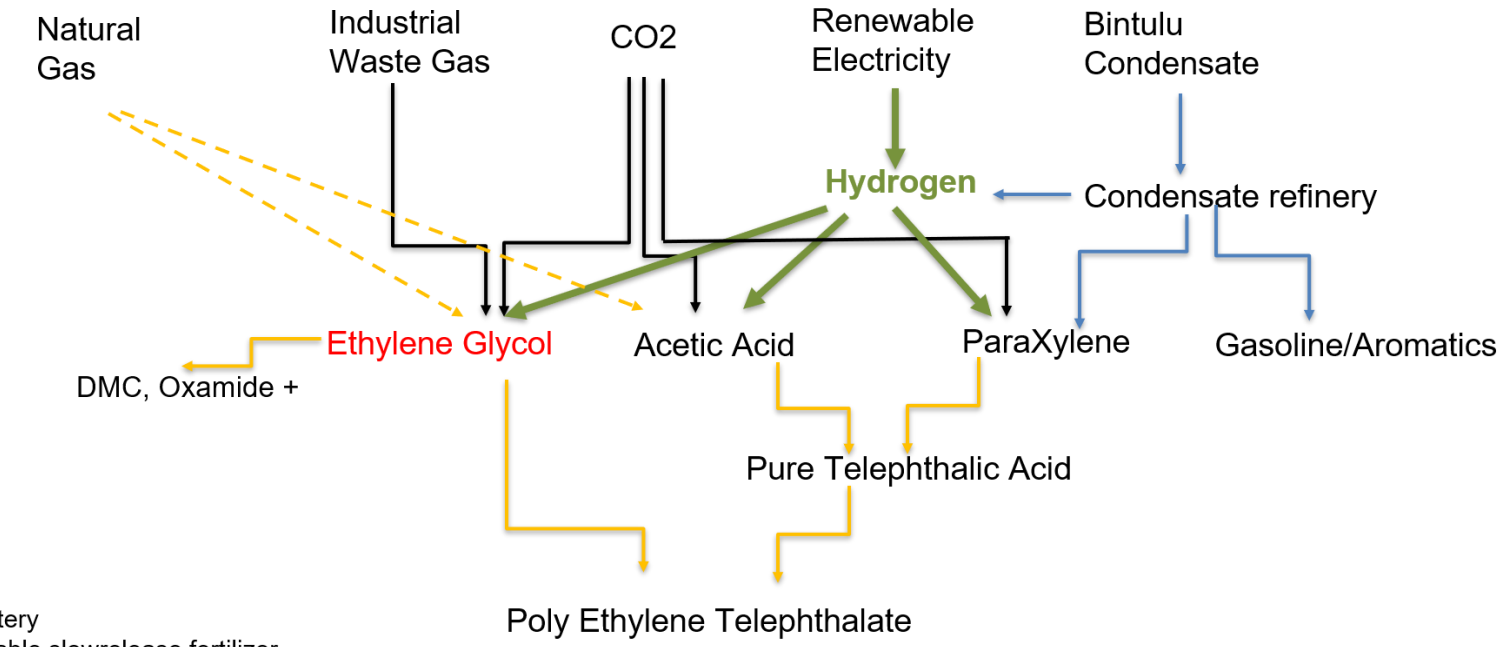
Transition to larger industrial $CO_2$ feeds with renewable Hydrogen competitively supplied.

## Full Circularity (Phase 3)

Integrate carbon capture and utilization processes industrially.

## Recycling (Phase 4)

Further development of downstream industries for the world largest and green supply chain.




*DMC: electrolyte for Lithium Ion Battery
*Oxamide: GHG reducing biodegradable slowrelease fertilizer

# Syngas to EG(SEG) Project in Sarawak



Both Sarawak Petchem and HighChem have conducted pre-Feasibility Study (FEL-1) for SEG Project in Kidurong and through FEL-1 confirmed to be economically and technically feasible.

While after completion of FEL-1 study we found that the Samalaju Industrial Park has well-developed infrastructure: it is a hub for renewable power, hosts ferromanganese production facilities with available off-gas, and has a port accessible to large Handymax-size vessels. Hence, HighChem and Indorama together with other Sarawakian parties are about to start detailed Feasibility Study (FEL-2) for SEG Project in Samalaju in 2026. We expected to start up the SEG Project in Samalaju sometimes in 2030.

**Phase 1/2**

HighChem INDORAMA VENTURES

Natural Gas

Industrial Off-gas

SEG Project → MEG 300ktpa

Utilities : ▲41kt-$CO_2$

CO 160ktpa

$CO_2e$ 252kt-$CO_2$

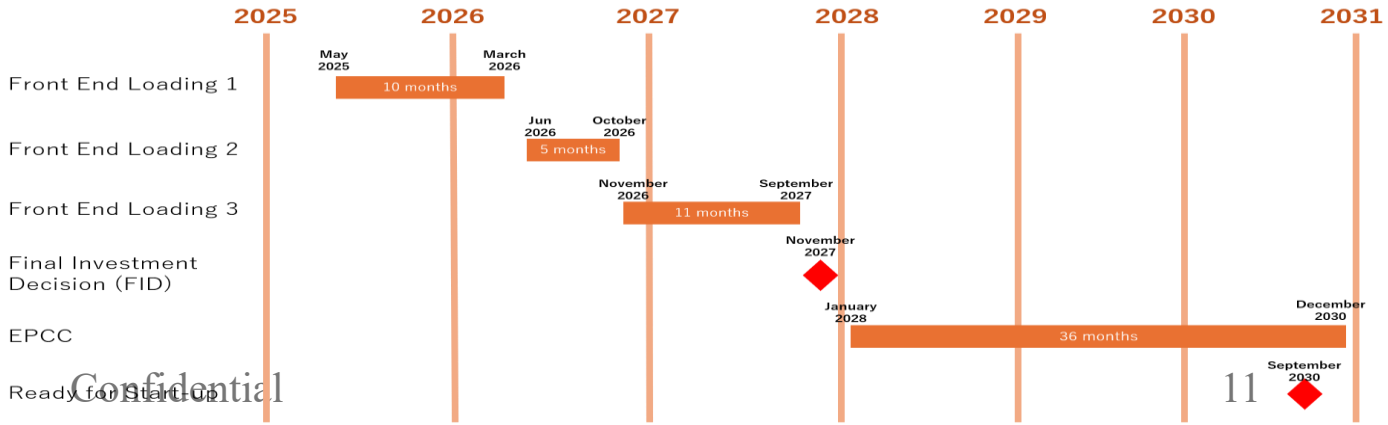
**Total $CO_2$ reduction 211kt-$CO_2$**

## Summary of pre-Feasibility Study (FEL-1)

| Case | Capacity | 300ktpa |
|---|---|---|
| **Total Investment** | Million USD | **508** |
| **(Base Scenario) Medium Crude Oil ($73/bbl)** | Project IRR [All Equity basis] | **16.67%** |
| | NPV (USD Mil) | **406.5** |
| | Payback years | **7** |
| (Reference Scenario) Low Crude Oil ($50/bbl) | Project IRR [All Equity basis] | 14.15% |
| | NPV (USD Mil) | 226.5 |
| | Payback years | 8 |
| (Reference Scenario) High Crude Oil (110 $/bbl) | Project IRR [All Equity basis] | 20.72% |
| | NPV (USD Mil) | 672.2 |
| | Payback years | 5 |

* Discount rate for NPV calculation : 10%

## Possible Timeline for SEG Project



# Possible derivatives and MEG related products

(*) : HighChem's Proprietary license

CO

Sarawak Ammonia Plant & Project

$NH_3$

DMO

$H_2$

MEG(*)

DMC(*)

DEC

EMC

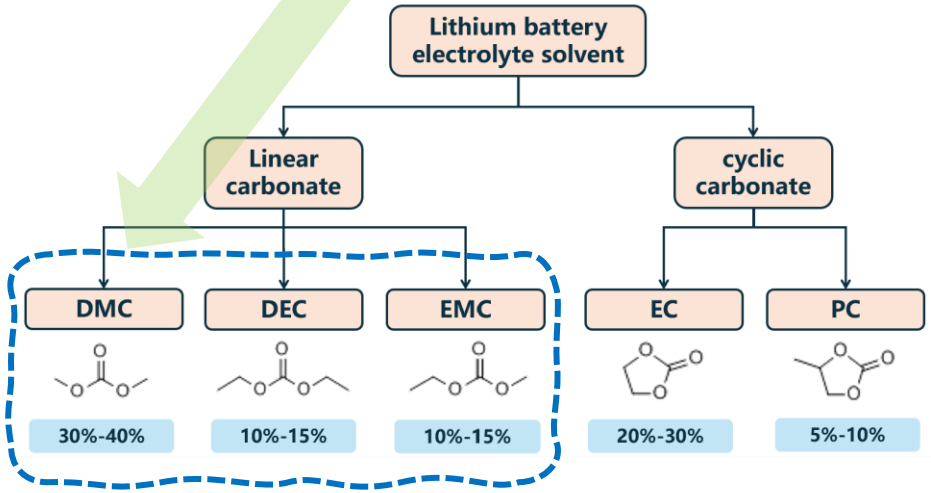
DMET(*)

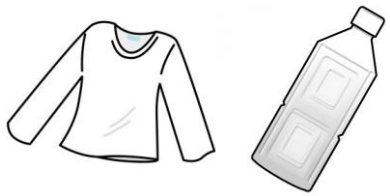
Oxamide(*)

・Non-Plastic Coating
・High Nitrogen absorbent to Crops


High Performance Fertilizer
(Slow-Release Fertilizer)

Lithium Battery
Electrolyte Solvent



Polyester (Fiber & Resins)

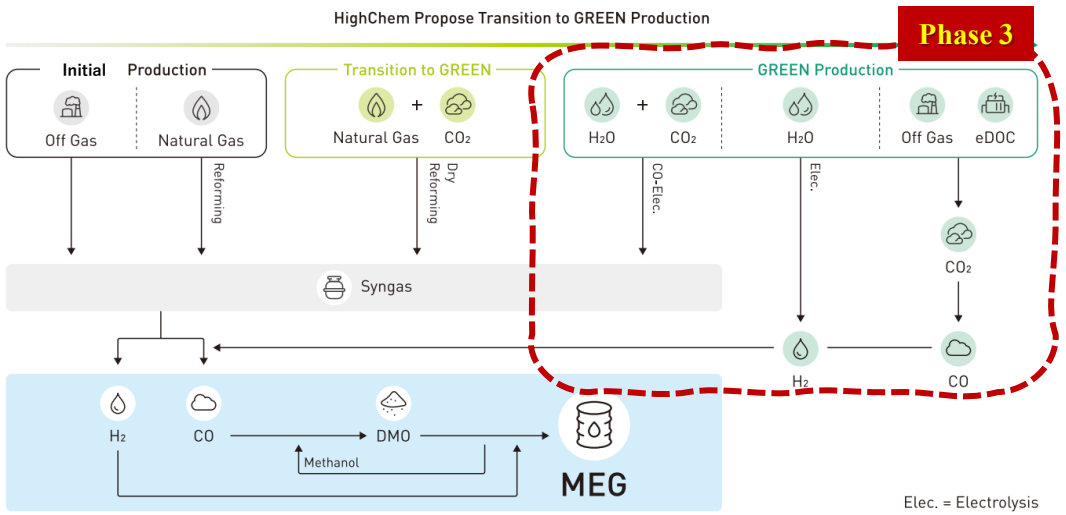
PTA

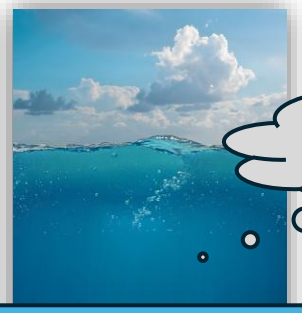
PX

Condensate Refinery

Bintulu Condensate
(Super High Concentrated Aromatics)

# Key Technologies for $CO_2$ Utilization



Capturing atmospheric $CO_2$ through Sea Water

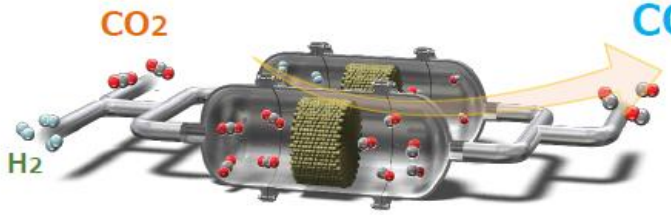
e-DOC
(Direct Ocean Capture)

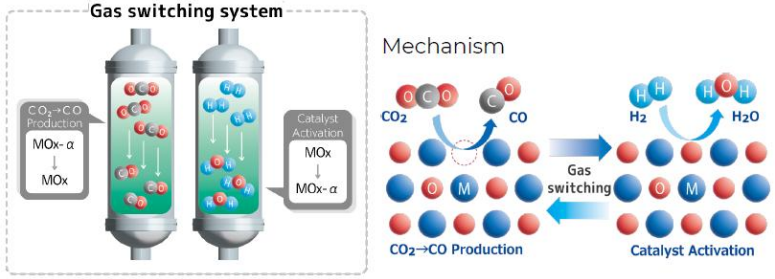
HighEnergy

$CO_2$

SEKISUI

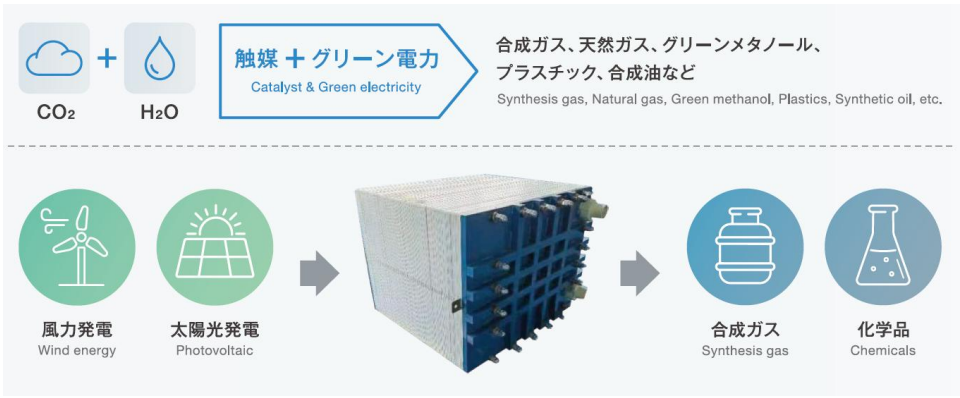
Chemical Looping




HighEnergy

$CO_2$ Electrolysis
(co-electrolysis)



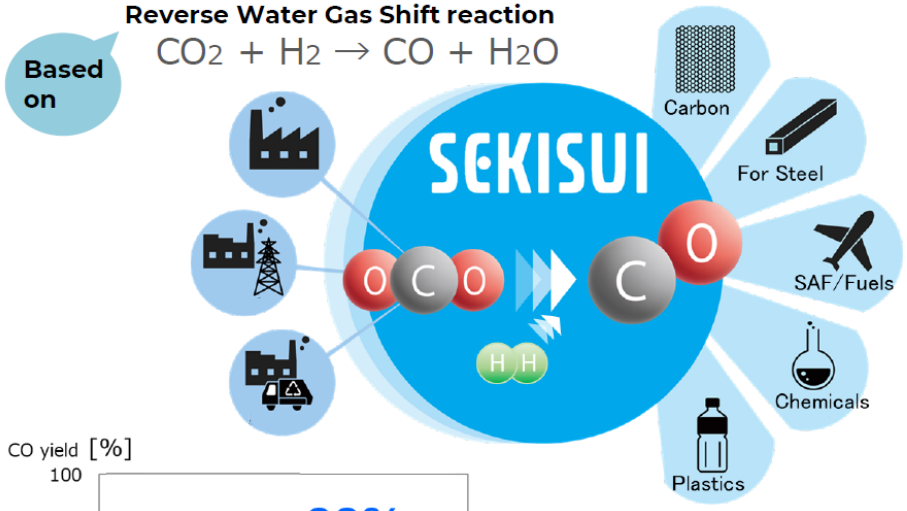
# Innovative CCU technology ($CO_2$ conversion into CO)

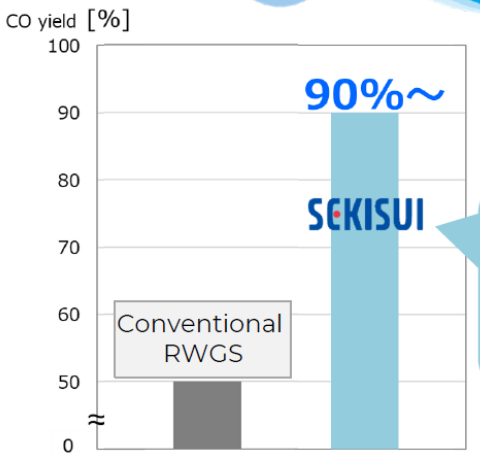
## Turning $CO_2$ into Value
## - CO as a Platform Molecule for Carbon Recycling -

Based on

**Reverse Water Gas Shift reaction**

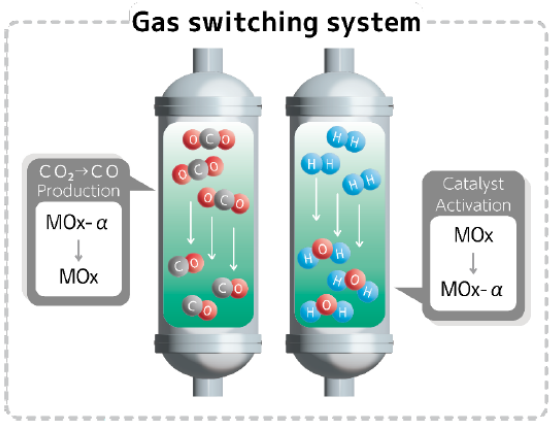
$CO_2 + H_2 \rightarrow CO + H_2O$



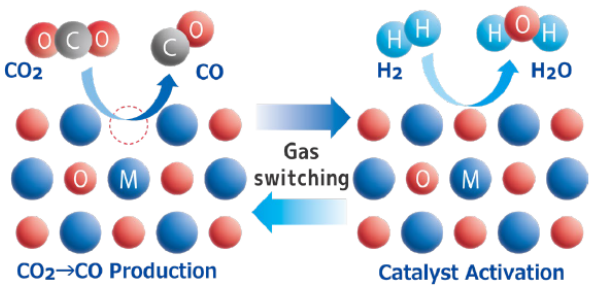




provides
**2 times higher**
performance
than conventional RWGS

## Proprietary technology : Chemical Looping




Mechanism




## Advantages

**90% over** — **CO yield**
Breaks the equilibrium limitation
Enables productive, efficient $CO_2$ utilization

**80% over** — **$H_2$ conversion**
Minimizes green $H_2$ loss
Improves economics

**Robust-ness** — **Against impurities**
Adaptable to various $CO_2$ source
Provides long-lasting performance

SEKISUI

# Roadmap
towards deployment

ArcelorMittal

**Demonstration completed**

**0.1~1kg-$CO_2$/day**

**Under operation**

Fixed catalyst bed & heater tubes

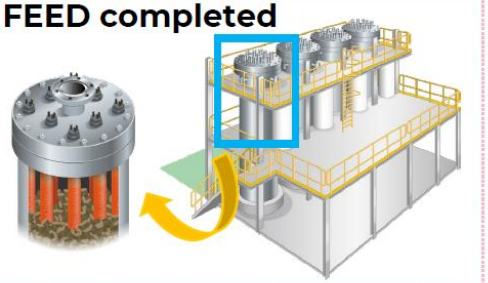
**1kg-$CO_2$/day**

**Under construction**

**0.1ton-$CO_2$/day**

ArcelorMittal

**FEED completed**



**1ton-$CO_2$/day**

**10ton-$CO_2$/day**

**100~1000 ton-$CO_2$/day**

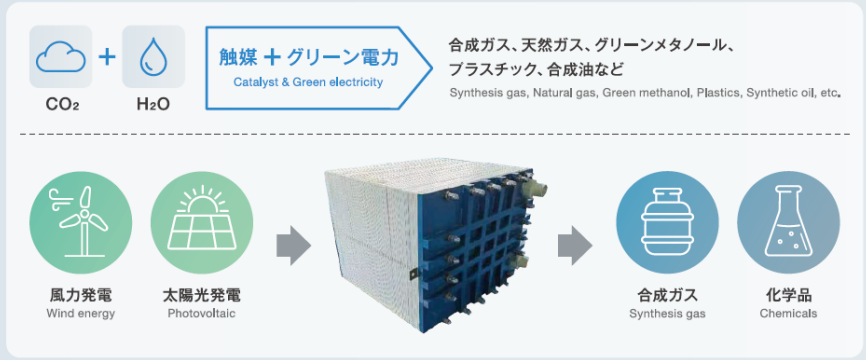
| TRL | 2 – 3 | 4 – 5 | 6 | 7 – 8 | 9 |
|---|---|---|---|---|---|
| | 2019 – 2022 | 2023 – 2024 | 2025 | 2026 – 2027 | 2028 | 2032 |

Deployment via technology license

## 01 電気化学的 炭素回収・利用（eCCU）
Electrochemical Carbon Capture and Utilization (eCCU)

**電気化学的　炭素回収・利用（eCCU）とは、排ガスから$CO_2$を効率的に回収し、電力を組み合わせることで、CO、ギ酸、アルコールなどの高付加価値な化学品にワンステップで変換することをいいます。eCCU技術により、炭素回収のコストを大幅に削減することが可能です。**

The integrated technology of eCCU means that $CO_2$ can be efficiently captured from the flue gas and then converted into CO, formic acid, alcohols and other high value-added chemicals in one step by combining with electrical power. It significantly cuts down the cost of carbon capture.




### 技術的優位性

電解質中の$CO_2$と$H_2O$が原料として使用されます。電気化学の工程で、$CO_2$と$H_2O$はカソード触媒で電子を受け入れて合成ガス（$CO+H_2$）に変換されます。同時に、水はアノード触媒で電子を放出し、$O_2$を生成します。このプロセスでは$CO_2$と$H_2O$のみが消費され、電解質は消費されません。

Technical Advantage

$CO_2$ and $H_2O$ in electrolyte are used as feedstocks. In the presence of electric energy, $CO_2$ and $H_2O$ are converted into synthesis gas ($CO+H_2$) by accepting electrons at the cathode catalyst. At the same time, water releases electrons at the anode catalyst and forms $O_2$. Only $CO_2$ and $H_2O$ are consumed in the process, and no electrolyte is consumed.

### 規格

| シングルスタック$CO_2$処理<br>Single stack $CO_2$ treatment | 適用可能な$CO_2$濃度<br>Applicable $CO_2$ concentration | 合成ガス濃度<br>Syngas concentration |
|---|---|---|
| 50～2000tons/year | 10～100% | ≥85% |
| **合成ガス比率（$H_2$/Co）<br>Syngas ratis ($H_2$/CO)** | **電力消費量<br>Electricity consumption** | **電極寿命<br>Electrode service life** |
| 1/0.2～1/1 | ≤6.5kwh/Nm³ | 5～7years |

## 02 $CO_2$電解技術・関連プロジェクト
Progress and Projects of $CO_2$ Electrolysis Technology

### 世界初の$CO_2$電解合成ガス製造実証プロジェクト

世界初となる$CO_2$電解を利用した合成ガス製造の実証プラントが、中国の石炭化学コンビナートにて完成しました。

**The World's first "Carbon dioxide electrolysis to synthesis gas"**

Completion of the world's first demonstration project "Carbon dioxide electrolysis to synthesis gas", which fully utilizes the potential of coal chemistry.

### 国家能源集团による実証プロジェクト

中国の国家能源集団は、圧力反応システムによる「電気化学的炭素回収・利用（eCCU）プロセス」実証プロジェクトを100トン/年規模で完成しました。

本実証プラントにおける電力消費量は6.7kWh/Nm³未満、$CO_2$転換率は50%以上、電解セルの反応面積は10000cm²、電流密度は80mA/cm²に達し、システムの最大圧力は1.2MPa、合成ガスのCO/$H_2$比は0.3～0.6となりました。

National Energy Group New Energy Technology Research Institute

Completed the demonstration project of the "Carbon dioxide pressurized eCCU process" by the pressure reaction system. The electricity consumption is less than 6.7kWh/Nm³, the carbon dioxide conversion rate is greater than 50%, the electrolytic cell reaction area is 10000cm², the current density reaches 80mA/cm², the maximum system pressure is 1.2Mpa, the CO/$H_2$ ratio of the synthesis gas is 0.3-0.6.

### 横山煤電公司による「$CO_2$電解合成ガス製造・基幹技術」研究・実証プロジェクト

本プロジェクトは「$CO_2$濃縮・変換一体化技術」を採用し、500トン/年の$CO_2$電解による合成ガス製造の工業実証研究を展開しています。火力発電所の排ガスを原料とし、電気分解により$CO_2$を合成ガスに転換することで、さらに高付加価値かつ持続可能な化学品及び液体燃料の生産が可能となります。

更に、カーボンエナジーでは、数万トンレベルの$CO_2$転換利用の工業化技術確立を目指しており、火力発電業界における$CO_2$の資源化利用に向け、新たな道筋を切り拓いています。

Research and demonstration project on key technologies for carbon dioxide electrolysis to synthesis gas at Hengshan Power Plant

This project will apply the integrated technology of carbon dioxide enrichment and conversion and conduct industrial demonstration research on 500 tons of carbon dioxide electrolysis into synthesis gas per year. Using flue gas from thermal power plants as feedstock, carbon dioxide will be converted into syngas by electrolysis, which in turn can be used to produce high value-added chemicals and sustainable liquid fuels. The project aims to develop an industrial technology for the conversion and utilization of tens of thousands of tons of carbon dioxide and is expected to open a new path for the resource utilization of carbon dioxide in the thermal power industry.

# Thank you